Claims

1. A method for coding audio data comprising a sequence of digital audio samples, including the steps of:

i) multiplying the input samples with a first trigonometric function factor to generate an intermediate sample sequence;

ii) computing a fast Fourier transform of the intermediate sample sequence to generate a Fourier transform coefficient sequence;

iii) for each transform coefficient in the sequence, multiplying the real and imaginary components of the transform coefficient by respective second trigonometric function factors, adding the multiplied real and imaginary transform coefficient components to generate an addition stream coefficient, and subtracting the multiplied real and imaginary transform coefficient components to generate a subtraction stream coefficient;

iv) multiplying the addition and subtraction stream coefficients with respective third trigonometric function factors; and

v) subtracting the corresponding multiplied addition and subtraction stream coefficients to generate audio coded frequency domain coefficients.

2. A method for coding audio data as claimed in claim 1, wherein the audio coded frequency domain coefficients comprise modified discrete cosine transform coefficients.

3. A method for coding audio data as claimed in claim 1 or 2, wherein the first trigonometric function factor for each audio sample is a function of the audio sample sequence position and the number of samples in the sequence.

4. A method for coding audio data as claimed in claim 3, wherein the respective second trigonometric function factors for each transform coefficient in the sequence are respective functions of the transform coefficient sequence position and the number of coefficients in the sequence.

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5. A method for coding audio data as claimed in claim 4, wherein the respective third trigonometric function factors are respective functions of the transform coefficient sequence position.

6. A method for coding audio data as claimed in claim 5, wherein step i) comprises multiplying the input sequence samples $x[n]$ by the first trigonometric function factor $cos(\pi n/N)$ to generate the intermediate sample sequence, where:

$x[n]$ are the input sequence audio samples;

N is the number of input sequence audio samples; and

$n = 0,\ldots,N-1$.

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7. A method for coding audio data as claimed in claim 6, wherein step ii) comprises computing the fast Fourier transform of the intermediate sample sequence so as to generate said transform coefficient sequence $G_k = g_{k,r} + jg_{k,i}$, where:

G_k is the transform coefficient sequence;

$g_{k,r}$ are the real transform coefficient components;

$g_{k,i}$ are the imaginary transform coefficient components; and

$k = 0,\ldots,(N/2-1)$.

8. A method for coding audio data as claimed in claim 7, wherein step iii) comprises determining the addition stream coefficients T_2 and subtraction stream coefficients T_1 according to:

$$T_1 = g_{k,r}\, cos(\pi(k+1/2)/N) - g_{k,i}\, sin(\pi(k+1/2)/N)$$

$$T_2 = g_{k,r}\, cos(\pi(k+1/2)/N) + g_{k,i}\, sin(\pi(k+1/2)/N)$$

where T_1 and T_2 are the subtraction stream and addition stream coefficients, respectively.

9. A method for coding audio data as claimed in claim 8, wherein steps iv) and v) comprise generating the audio coded frequency domain coefficients X_k according to:

$$X_k = T_1\, cos(\pi(2k+1)/4) - T_2\, sin(\pi(2k+1)/4)$$

where X_k are the audio coded frequency domain coefficients; and $cos(\pi(2k+1)/4)$ and $sin(\pi(2k+1)/4)$ are the third trigonometric function factors.

10. A method for coding audio data, including the steps of:

combining first and second sequences of digital audio samples from first and second audio channels into a single complex sample sequence;

determining a Fourier transform coefficient sequence as defined in any preceding claim;

generating first and second transform coefficient sequences by combining and/or differencing first and second selected transform coefficients from said Fourier transform coefficient sequence; and

for each of the first and second transform coefficient sequences, generating audio coded frequency domain coefficients as defined in any preceding claim, so as to generate respective sequences of said audio coded frequency domain coefficients for the first and second audio channels.

11. A method for coding audio data as claimed in claim 10, wherein the step of generating first and second transform coefficient sequences comprises, for each corresponding coefficient in the first and second transform coefficient sequences, selecting first and second transform coefficients from said Fourier transform coefficient sequence, determining a complex conjugate of said second transform coefficient, combining said first transform coefficient and said complex conjugate for said first transform coefficient sequence and differencing said first transform coefficient and said complex conjugate for said second transform coefficient sequence.

12. A method for coding audio data as claimed in claim 10 or 11, wherein the multiplying step i) comprises multiplying the input sequence samples $z[n]$ by the first trigonometric function factor $cos(\pi n/N) + jsin(\pi n/N)$ to generate the intermediate sample sequence, where:

$z[n] = x[n] + jy[n]$ is the complex sample sequence;

$x[n]$ is the first sequence of digital audio samples;

$y[n]$ is the second sequence of digital audio samples;

N is the number of input sequence audio samples in each sequence;

$n = 0,\ldots,N-1$; and

j is the complex constant.

13. A method for coding audio data as claimed in claim 11 or 12, wherein said first and second transform coefficient sequences are generated according to:

$$G_k = (Z_k + Z^*_{N-k-1})/2$$

$$G'_k = (Z_k - Z^*_{N-k-1})/2j$$

where G_k is said first transform coefficient sequence;

G'_k is said second transform coefficient sequence;

N is the number of input sequence audio samples;

$k = 0,\ldots,(N/2-1)$;

Z_k is said first transform coefficient;

Z^*_{N-k-1} is the complex conjugate of said second transform coefficient; and

j is the complex constant.

14. A method for coding audio data as claimed in any one of claims 10 to 13, including examining said first and second sequences of digital audio samples to determine a short or long transform length, and coding the audio samples using a short or long transform length as determined.

15. A method for coding audio data comprising sequences of digital audio samples from a plurality of audio channels, comprising determining a transform length for each of the channels, pairing the channels according to their determined transform length, and coding the audio samples of first and second channels in each pair, as defined in any one of claims 10 to 13, according to the determined transform length.

16. A method for coding audio data as claimed in any preceding claim, including applying a windowing function in combination with said multiplying step i).

17. A method for coding audio data including the steps of:

obtaining at least one input sequence of digital audio samples;

pre-processing the input sequence samples including applying a pre-multiplication factor to obtain modified input sequence samples;

transforming the modified input sequence samples into a transform coefficient sequence utilising a fast Fourier transform; and

post-processing the sequence of transform coefficients including applying first post-multiplication factors to the real and imaginary coefficient components, differencing and combining the post-multiplied real and imaginary components, applying second post-multiplication factors to the difference and combination results, and differencing to obtain a sequence of modified discrete cosine transform coefficients representing said input sequence of digital audio samples.

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18. A method as claimed in claim 17, wherein the pre-multiplication factor, and first and second post-multiplication factors are trigonometric function factors.

19. A method as claimed in claim 18, wherein the pre-multiplication factor applied to each digital audio sample in the input sequence is a trigonometric function of the audio sample sequence position and the number of samples in the sequence.

20. A method as claimed in claim 18, wherein the first post-multiplication factors for each transform coefficient in the sequence are trigonometric functions of the transform coefficient sequence position and the number of coefficients in the sequence.

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21. A method as claimed in claim 18, wherein the second post-multiplication factor for each difference or combination result is trigonometric functions of the transform coefficient sequence position of the coefficients used in the difference or combination.

22. A method as claimed in any one of claims 17 to 21, wherein the pre-processing operations are performed on each sample in the input sequence individually.

23. A method as claimed in any one of claims 17 to 22, wherein the post-processing operations are performed on each transform coefficient in the sequence individually.

24. A method for coding audio data including the steps of:

obtaining first and second input sequences of digital audio samples corresponding to respective first and second audio channels;

combining the first and second input sequences of digital audio samples into a single complex input sample sequence;

pre-processing the complex input sequence samples including applying a pre-multiplication factor to obtain modified complex input sequence samples;

transforming the modified complex input sequence samples into a complex transform coefficient sequence utilising a fast Fourier transform; and

post-processing the sequence of complex transform coefficients to obtain first and second sequences of audio coded frequency domain coefficients corresponding to the first and second audio channels including, for each corresponding frequency domain coefficient in the first and second sequences, selecting first and second complex transform coefficients from said sequence of complex transform coefficients, combining the first complex transform coefficient and the complex conjugate of the second complex transform coefficient for said first channel and differencing the first complex transform coefficient and the complex conjugate of the second complex transform coefficient for said second channel, and applying respective post-multiplication factors to the combination and difference to obtain said audio coded frequency domain coefficients corresponding to the first and second audio channels.

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25. A method as claimed in claim 24, wherein the pre-multiplication factor for each sample in the complex input sample sequence comprises a complex trigonometric function of the complex input sample sequence position and the number of samples in the sequence.

26. A method as claimed in claim 24 or 25, wherein the post-processing for each of the first and second channels includes applying first post-multiplication factors to the real and imaginary coefficient components, differencing and combining the post-multiplied real and imaginary components, applying second post-multiplication factors to the difference and combination results, and differencing to obtain a sequence of modified discrete cosine transform coefficients representing said input sequence of digital audio samples.

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27. A method for coding audio data including the steps of:

obtaining first and second input sequences of digital audio samples $x[n]$, $y[n]$ corresponding to respective first and second audio channels;

combining the first and second input sequences of digital audio samples into a single complex input sample sequence $z[n]$, where $z[n] = x[n] + jy[n]$;

pre-processing the complex input sequence samples including applying a pre-multiplication factor $cos(\pi n/N) + jsin(\pi n/N)$ to obtain modified complex input sequence samples, where N is the number of audio samples in each of the first and second input sequences and $n = 0,\ldots,(N-1)$;

transforming the modified complex input sequence samples into a complex transform coefficient sequence Z_k utilising a fast Fourier transform, wherein $k = 0,\ldots,(N/2-1)$; and

post-processing the sequence of complex transform coefficients to obtain first and second sequences of audio coded frequency domain coefficients corresponding to the first and second audio channels X_k, Y_k according to:

$$G_k = (Z_k + Z^*_{N-k-1})/2 \qquad k=0..N/2-1$$

$$G'_k = (Z_k - Z^*_{N-k-1})/2j \qquad k=0..N/2-1$$

$$X_k = \cos\gamma * (g_{k,r}\cos(\pi(k+1/2)/N) - g_{k,i}\sin(\pi(k+1/2)/N) - \sin\gamma * (g_{k,r}\sin(\pi(k+1/2)/N) + g_{k,i}\cos(\pi(k+1/2)/N)$$

$$Y_k = \cos\gamma * (g'_{k,r}\cos(\pi(k+1/2)/N) - g'_{k,i}\sin(\pi(k+1/2)/N) - \sin\gamma * (g'_{k,r}\sin(\pi(k+1/2)/N) + g'_{k,i}\cos(\pi(k+1/2)/N)$$

where G_k is a transform coefficient sequence for the first channel;

G'_k is a transform coefficient sequence for the second channel;

$g_{k,r}$ and $g_{k,i}$ are the real and imaginary transform coefficient components of G_k;

$g'_{k,r}$ and $g'_{k,i}$ are the real and imaginary transform coefficient components of G'_k;

Z^*_{N-k-1} is the complex conjugate of Z_{N-k-1}; and

$\gamma(k) = \pi(2k+1)/4$.